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OCCUPATIONAL NOISE EXPOSURE REGULATION

Request for Review and Report

ENVIRONMENTAL PROTECTION AGENCY

[FRL 303-2]

PROPOSED OSHA OCCUPATIONAL NOISE EXPOSURE REGULATION

Request for Review and Report

I. SUMMARY

On October 24, 1974, the Occupational Safety and Health Administration (OSHA) of the Department of Labor, published proposed requirements and procedures respecting occupational noise exposures, 39 FR 37773. The Administrator of the Environmental Protection Agency (EPA) believes that the proposed regulation does not protect the public health and welfare to the extent required and feasible. Accordingly, under the authority of section 4(c)(2) of the Noise Control Act of 1972, Pub. L. 92-574 section 4(c)(2), 86 Stat. 1236, 42 USC 4903 (c)(2), the Administrator of EPA hereby requests that the Secretary of Labor review the proposed occupational noise exposure regulation and report to the Administrator of EPA on the advisability of revising such regulation to provide the required protection of the public health and welfare. Such report shall be forwarded to the Administrator of EPA 90 days from the date of this notice, and, as required by section 4(c)(2) of the Noise Control Act, shall be published in the FEDERAL REGISTER, accompanied by a detailed statement of the findings and conclusions of the Secretary of Labor respecting the revision of the regulation.

As presently proposed, the allowable level for an eight-hour workday exposure, 90 dBA, is too high. The Administrator believes that the eight-hour level should be set at 85 dBA, to become effective within three years, with a commitment to reduce to lower levels at a later date when such a reduction is shown to be feasible. Further, the OSHA formula for exposure of other than eight hours in length (the time-intensity tradeoff), allows an increase of 5 dB for each halving of exposure time. The Administrator recommends a 3-dB time-intensity tradeoff as necessary for protection of public health and welfare.

The development of an acceptable occupational noise exposure standard requires the resolution of three major issues: First, the requirements of public health and welfare; next, whether the technology exists to implement the standard necessary to protect health and welfare; and third, whether the costs of implementing such a standard are justified by the need.

EPA believes that there is sufficient information available to address each of these issues. OSHA states, however, that the 90-dBA standard should remain in effect "until further empirical data and information on the health risk, feasibility, and economic impact indicate the practicability and necessity of an 85-dBA requirement" (39 FR 37773). The current standard should not be extended on this basis.

EPA has provided OSHA with sufficient data to support the necessity for reducing the standard to 85 dBA, or lower. EPA has recently published a large amount of information on the effects of noise,[1-5] culminating in a document entitled, *Information on Levels of Environmental Noise Requisite to Protect the Public Health and Welfare with an Adequate Margin of Safety*[6] (March, 1974), that was required by the Noise Control Act of 1972. This document was subjected to an exhaustive review both by the scientific community and by other Federal agencies. The specified levels and the methodology used to identify them have been endorsed by a subcommittee of the Committee on Hearing, Bioacoustics and Biomechanics (CHAPA), of the National Academy of Sciences—National Research Council. EPA does not believe the health justification for a lower occupational noise level requires further study. EPA's criteria support a level of 75 dBA for an ultimate health goal;[6] EPA believes that reduction to 85 dBA is an important step toward this goal.

The National Institute of Occupational Safety and Health (NIOSH), under the authority of sections 20(a)(3) and 22(c)(2) of the Occupational Safety and Health Act, Pub. L. 91-596, 42 USC 669(a)(3), 671(c)(2) (1970), developed and provided criteria to OSHA for a recommended standard, Occupational Exposure to Noise.[7] These criteria clearly stated the need for reducing the eight-hour exposure level to 85 dBA and the accompanying data and background material support that conclusion.[7]

In the preamble to the proposed standard, OSHA states that NIOSH "reluctantly concurs" with the 90-dBA level at the present time. The entire text of this NIOSH statement is as follows:

> Currently NIOSH reluctantly concurs with the generally acceptable 90 dBA occupational exposure level for an 8-hour day. The need for reducing this 8-hour exposure level to 85 dBA, as supported by the material contained in this document is also recognized. It is recommended that the 85-dBA, 8-hour exposure level be applicable to all newly designed occupational exposure environments after 6 months from the effective date of this standard. However, due to the unavailability of sufficient data relating to the technological feasibility of meeting the 85-dBA level, NIOSH is unable to recommended a specific time period after which the 85 dBA, 8 hour occupational exposure level might become effective for all occupational noise environments. (*Occupational Exposure to Noise*, p. II-3.)

This inability to comment on technological feasibility is not surprising in view of the fact that NIOSH's responsibility, as articulated in section 20(a)(3) of the Occupational Safety and Health Act, is to evaluate and recommend safe levels of exposure without regard to economics or technological feasibility.

As to technological feasibility, the Department of Labor contracted for an independent study on the feasibility of implementing both 90- and 85-dBA standards, and the results of that study were published on January 1, 1974.[8] The study concluded that compliance with an 85-dBA standard can be achieved using currently existing technology and that the noise control industry is capable of responding adequately to the increase in demand.[8] This study also explored the relative costs to industry of complying with the current 90-dBA level and an 85-dBA level over three- and five-year compliance periods. EPA believes that the resulting cost estimates are inflated and do not reflect the various economic alternatives to the industry-wide, threshold limit approach to the setting of standards.

EPA, charged, under section 4(c)(1) of the Noise Control Act, with the role of coordinating Federal noise control efforts, has worked with OSHA staff members during the development of the proposed regulation. An EPA representative served as non-voting liaison member to OSHA's Standards Advisory Committee on Noise. OSHA's proposed standard and draft Environmental Impact Statement were reviewed extensively by EPA staff,[9] resulting in suggestions for substantial changes and improvements to the standard and EIS.

The most significant recommendations involved reduction to 85 dBA within a 3-year period and adoption of the 3-dB time-intensity tradeoff. EPA also recommended a more conservative standard for impulse noise so that the maximum level would be decreased by 10 dB for each ten fold increase in the number of impulses. Another recommendation was that the definition of significant threshold shift be improved so that shifts of more than 10 dB at any test frequency would be considered significant. All of EPA's suggested improvements, with the exception of the impulse standard, have been rejected without adequate explanation.

EPA has also made several suggestions aimed at ameliorating the cost impact of a more protective standard. These suggestions include the alternatives of industry-by-industry standards, incremental reductions over time, a stringent standard with variance provisions, and lower levels for new plants. These, too, have been rejected without explanation. None of these recommendations are discussed in the preamble to OSHA's proposal. For these reasons, EPA is resorting to the procedures of section 4(c)(2) of the Noise Control Act in asking for a review of the proposed standard. The Act requires that the Department of Labor complete the requested review and report its findings and conclusions to the Administrator.

II. HEALTH AND WELFARE EFFECTS

A. NOISE EXPOSURE LEVEL

OSHA's Proposed Time-Weighted Level: 90 dBA
EPA's Recommendation: Within Three years: 85 dBA
Later Date: 80 dBA

Supporting information. EPA has reviewed OSHA's proposed standard for occupational exposure to noise and in view of the best available data, has determined that the 90-dBA time weighted

level for an 8-hour day does not adequately protect public health and welfare. EPA has identified a level of approximately 20 decibels below OSHA's proposed 90 dBA as the safe level for protection against hearing loss, i.e., a yearly equivalent sound level of 70 dBA averaged over a 24-hour period (L eq(24) 70).[9] The 70 dBA level would be compatible with an 8-hour exposure level of 75 dBA, so long as the exposure level over the remaining 16 hours is sufficiently low to result in a negligible contribution to the 24-hour average, i.e., no greater than an equivalent sound level of 60 dBA. EPA's criterion for the identified level is that it should produce no more than a 5-dB hearing loss at the 4000-Hz frequency over a period of 40 years in virtually the entire population. Although the identified safe level is not a standard, it provides a basis for judgment in the setting of standards. In that sense, it should be considered a long-range public health goal.

The data on which EPA's criteria and recommended levels are based have been drawn from three significant bodies of data, those of Baughn,[5] Passchier-Vermeer,[10] and Robinson.[11] EPA's conclusions are drawn from the averaged data of more than 10,000 subjects from the 12 studies reported by the above researchers. EPA believes these data represent the best available evidence on the effects of noise on hearing. As will be shown below, regardless of the criteria used to predict the effects of noise on the hearing of exposed workers, 8-hour noise levels of 90 dBA represent an unacceptable health hazard.

1. *Noise induced permanent threshold shift (NIPTS).* EPA believes that OSHA's analysis, based upon hearing risk for the averaged frequencies of 500 Hz, 1000 Hz and 2000 Hz, is inadequate, because it fails to account for hearing loss in the critical frequencies above 2000 Hz, which are the soonest and most severely affected by exposure to noise. To account for those factors, EPA has analyzed hearing loss in terms of noise induced permanent threshold shift (NIPTS),[4, 6] and has examined hearing loss at individual frequencies and various combinations of frequencies,[4] giving special emphasis to the changes in response to higher frequencies. It should be borne in mind that for each 10 dB of hearing loss, sound energy will have to be increased by a factor of 10 in order for a particular sound to be heard.

The most important use of the hearing mechanism in today's society is for hearing and understanding speech. The kind of hearing loss that results from noise exposure impairs this ability to communicate. This impairment is usually a gradual occurrence. Individuals who have begun to suffer such a loss will often notice that ordinary speech is just as loud, but not as distinct as previously. This phenomenon occurs with reduction of high frequency hearing since a considerable portion of the sound energy of consonants lies in the high frequency range. Unfortunately for hearing-impaired individuals, the energy in consonants is smaller in magnitude as well as higher in frequency than it is for vowels, and it is consonants much more than vowels that give intelligibility to English speech.[26, 28] As noise-induced hearing loss increases, speech communication becomes progressively more difficult for the hearing-impaired listener.

OSHA's analysis is based upon studies which have shown that in order to understand undistorted speech in quiet conditions (sound-proofed rooms), 500 Hz, 1000 Hz and 2000 Hz are the most important audiometric frequencies.[14, 15] However, undistorted speech in quiet surroundings is not characteristic of the typical conditions in which speech must be understood. NIOSH[7] cites modern research as showing that "* * * everyday communication is placed under a wide variety of environmental stresses. Estimates of the amount of time that speech is distorted range from a conservative figure of 50 percent[28] up to about 100 percent." [17] It is obvious that everyday communication does not usually take place in sound-proofed booths.

It has been demonstrated that in order to understand speech in less than optimal conditions good hearing in the frequencies above 2000 Hz is very important. As far back as 1947, French and Steinburg[18] showed in a classic study that the frequencies above 1900 Hz are as important as those below 1900 Hz for determining the intelligibility of speech. There have been numerous other significant studies on the understanding of speech under various conditions of noise and distortion which are typical of environmental situations,[19-28] which point to the importance of preserving hearing above 2000 Hz. While these studies do not minimize the importance of good hearing in the mid-frequencies, they emphasize the previously underrated need for perception of frequencies in the range of 3000 Hz and 4000 Hz. Thus, while examining the effects of noise on hearing it is important to assess the effects on perception of the high frequencies as well as the mid-frequency range.

Figures 1 and 2 show the effects of noise on human response to various audiometric frequencies as a function of exposure level. Figure 1 shows the median NIPTS for ten years as a function of exposure level, according to Passchier-Vermeer.[4, 10] Figure 2 shows these effects for an exposure of forty years.[27] It can be seen that while damage to hearing at the 4000-Hz frequency occurs mostly during the first 10 years, other critical frequencies, such as 2000 Hz and 3000 Hz continue to be affected as exposure is prolonged. It is also noteworthy that the important 2000 Hz frequency is considerably more affected by an exposure level of 90 dBA than by a level of 85 dBA.

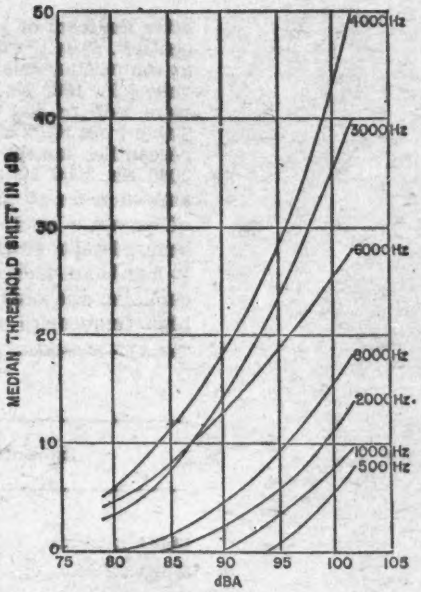

Figure 1. Median Noise-Induced Permanent Threshold Shift in dB as a Function of Exposure Level 8 hours a day for a period of 10 years.[10]

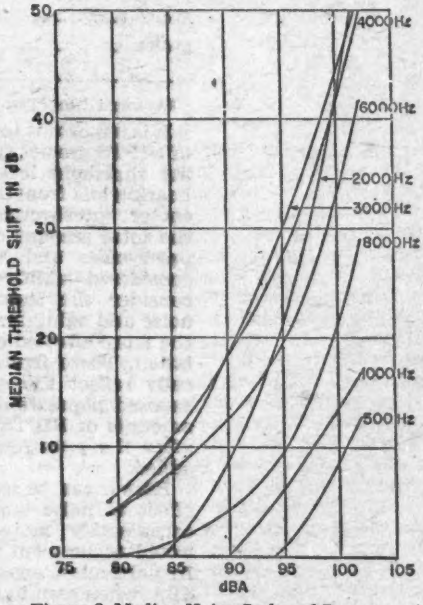

Figure 2. Median Noise-Induced Permanent Threshold Shift in dB as a Function of Noise Exposure Level 8 hours per day for a Period of 40 Years.[27]

Since there appears to be considerable variation in individual susceptibility to NIPTS, it is important to examine the effects of noise on the more affected portion of the population by looking at the higher percentiles. Using data from Passchier-Vermeer [4, 10] and Robinson [4, 11] EPA calculated amounts of NIPTS incurred

See footnotes at end of document.

after numbers of years for various percentiles. Baughn's data were not included in the calculations since discrete NIPTS values for 1000 Hz, 2000 Hz and 3000 Hz were not readily available. Shown in Table 1 are NIPTS for the 50th and 90th percentiles for the frequencies 1000 Hz, 2000 Hz, 3000 Hz and 4000 Hz after 10 and 40 years of exposure as a function of exposure level. Note that at an exposure level of 80 dBA the median NIPTS is less than a decibel for the mid-frequencies, and only reaches 5 dB in the high frequencies after 40 years of exposure. Although more hearing loss is incurred by the 10 percent most susceptible (the 90th percentile), losses due to 80 dBA can still be considered slight. An exposure level of 85 dBA produces nearly twice as much NIPTS as the 80 dBA level and likewise the NIPTS for most frequencies doubles between 85 dBA and 90 dBA for both groups. Although the increase of NIPTS at 4000 Hz appears to level off somewhat between 85 dBA and 90 dBA, there is significant increase in NIPTS at 2000 Hz. This value more than doubles between the exposure levels of 85 dBA and 90 dBA.

TABLE I.[1]—*Noise-induced permanent threshold shift (NIPTS) in decibels as a function of noise exposure level for the 50th and 90th percentiles*

[In decibels]

Exposure level	Years	Audiometric frequency			
		1000 Hz	2000 Hz	3000 Hz	4000 Hz
		(a) 50th percentile			
80 dBA	10	0.2	0.5	3.0	4.3
	40	0.55	1.1	4.8	5.8
85 dBA	10	0.4	1.1	5.6	8.0
	40	0.9	2.5	8.7	10.4
90 dBA	10	0.8	3.0	10.7	13.4
	40	1.7	8.2	16.0	17.2
		(b) 90th percentile			
80 dBA	10	0.6	1.3	4.6	10.2
	40	1.3	2.75	7.8	13.4
85 dBA	10	1.1	3.7	8.3	14.7
	40	2.3	6.7	13.4	19.2
90 dBA	10	2.1	7.8	17.5	21.2
	40	4.2	14.9	24.8	26.6

[1] Averaged data of Passchier-Vermeer [9] and Robinson.[11]

It is important to remember that values of NIPTS are not synonomous with hearing threshold levels. As age increases, hearing loss from the natural aging process or "presbycusis" will contribute to the total amount of hearing loss. Since presbycusis and NIPTS are generally considered additive,[5, 10] it is helpful to consider the summed contribution of noise and aging for the average, and for the more affected elements of the population. These figures will more realistically reflect the effect of noise on an exposed population. Table II shows the amounts of NIPTS described in Table I after the presbycusis values have been added.

Here it can be seen that the combined effect of noise and aging will produce considerably more hearing loss than would occur from noise exposure alone. In particular, exposure to a level of 90 dBA, when seen in combination with the aging process, results in substantial losses for average workers while affecting the 90th percentile even more severely.

See footnotes at end of document.

In order to judge the magnitude of this effect, these exposure levels and the resulting NIPTS can be related to numbers of noise exposed workers. OSHA's contractor, Bolt, Beranek and Newman (BBN), has estimated the percentage of production workers currently exposed to various levels of noise, and the percentage that would be exposed to those levels if maximum compliance with the present 90-dBA standard or a future 85 dBA standard were achieved, Impact of Noise Control at the Workplace," 1974, pp. 13 & 26. (See Tables III and IV in text.) BBN defines maximum compliance as that which would be achieved with the full use of presently available technology. BBN estimates that unless new technology is developed approximately 8 percent of the workforce would continue to be exposed to noise levels above the required limit, whether that limit is 90 dBA or 85 dBA. According to BBN approximately 14 million workers are currently employed in American production industries. The number of noise exposed workers based on this figure have been entered in Tables III and IV.

TABLE II.—*Hearing threshold level in decibels* [1] *as a function of noise exposure and presbycusis*

[In decibels]

Exposure level	Age	Audiometric frequency			
		1000 Hz	2000 Hz	3000 Hz	4000 Hz
		(a) 50th percentile			
Nonnoise exposed	30	1.0	0.8	1.8	3.3
	60	6.8	11.3	18.0	24.0
80 dBA	30	1.2	1.3	4.8	7.6
	60	7.9	12.4	22.8	29.8
85 dBA	30	1.8	1.9	7.4	11.3
	60	8.6	13.8	26.7	34.4
90 dBA	30	2.6	3.8	12.5	16.7
	60	10.2	19.5	34.0	41.2
		(b) 90th percentile			
Nonnoise exposed	30	8.8	7.6	13.6	16.1
	60	14.6	18.1	29.8	36.8
80 dBA	30	9.4	8.9	18.2	26.3
	60	15.9	20.9	37.6	50.2
85 dBA	30	9.9	11.3	21.9	30.8
	60	16.9	24.8	43.2	56.0
90 dBA	30	10.9	15.4	31.1	37.3
	60	18.8	33.0	54.6	63.4

[1] Averaged Data of Passchier-Vermeer [10] and Robinson.[11] Presbycusis data previously subtracted by these authors have been added back.
[2] Re audiometric zero (ANSI S 3.6, 1969).

TABLE III.—*Estimates of shift in distribution of worker exposure due to maximum compliance to 90 dBA (according to Bolt, Beranek, and Newman, 1974)*

Exposure level (dBA)	Production workers currently exposed		Those exposed after maximum compliance to 90 dBA	
	Percent production workforce	Approximate number of workers	Percent production workforce	Approximate number of workers
80 to 84	30	4,200,000	30	4,200,000
85 to 89	40	5,600,000	62	8,680,000
90 to 94	15	2,100,000	4	560,000
95 to 99	7	980,000	2	280,000
100 to 104	4	560,000	1	140,000
105 to 109	2	280,000	1	140,000
110 to 114	2	280,000	0	
More than 115	1	140,000	0	

TABLE IV.—*Shift in distribution of worker exposure due to maximum compliance to 85 dBA (according to Bolt, Beranek, and Newman, 1974)*

Exposure level (dBA)	Production workers currently exposed		Those exposed after maximum compliance to 85 dBA	
	Percent production workforce	Approximate number of workers	Percent production workforce	Approximate number of workers
80 to 84	30	4,200,000	92	12,880,000
85 to 89	40	5,600,000	4	560,000
90 to 94	15	2,100,000	2	280,000
95 to 99	7	980,000	1	140,000
100 to 104	4	560,000	1	140,000
105 to 109	2	280,000	0	
110 to 114	2	280,000	0	
More than 115	1	140,000	0	

It can be seen that requiring compliance at either the 90 dBA or the 85 dBA level would be beneficial. However, the difference between compliance at 90 dBA and at 85 dBA as can be seen by comparing Table III and IV is particularly dramatic. Should compliance at 85 dBA be achieved, the numbers of noise exposed workers in the 85–89 dBA group would be reduced from 8,680,000 to only 560,000. Thus, approximately 8,120,000 workers would be prevented from suffering the amount of NIPTS resulting from exposures of 85 dBA to 90 dBA shown in Table I. In addition, the numbers of workers exposed to the more damaging noise levels between 90 dBA and 110 dBA would be reduced from approximately 1,120,000 to 560,000. Although some amounts of hearing loss would still occur as a result of an 85 dBA exposure level, EPA believes that the demonstrated differences between NIPTS resulting from exposure to 85 dBA as opposed to 90 dBA are so significant as to warrant reduction to the 85 dBA level. This significance becomes more profound when one considers that the hearing of 8 million workers is involved.

2. *Hearing risk.* Since the effects of occupational noise on hearing are often stated in terms of damage risk or hearing risk figures, it would be useful to examine percentages of the population at risk for various exposure levels. The word "risk" for these purposes is defined as the percentage of noise exposed population with a given amount of hearing impairment after subtractions have been made for the percentage of people who would "normally" incur such losses from other causes in the absence of noise. Criteria published by the International Organization for Standardization (ISO),[39] EPA,[2] and NIOSH,[7] are fairly similar. These criteria shown in Table V, are based on 8-hour exposures, 5 days per week for up to 40 years. They show percentages of people who will have hearing losses that exceed 25 dB[2] at the average audiometric frequencies of 500 Hz, 1000 Hz and 2000 Hz. It can be seen that substantial portions of the exposed population will incur such a hearing impairment at 90 dBA, approximately half as many will incur these impairments at 85 dBA, and the risk is quite small at 80 dBA.

TABLE V.—*Percentage of the population at risk (exceeding 25 dB hearing loss) as a result of various noise exposure levels*

Item	Noise exposure level (dBA)	Risk (percent)
a. Averaged frequencies 500 Hz, 1000 Hz, and 2000 Hz:		
ISO	90	21
	85	10
	80	0
EPA	90	22.3
	85	12
	80	5
NIOSH	90	29
	85	15
	80	3
b. Hearing risk for 4000 Hz:		
BAUGHN	90	52
	85	30
	80	6

These risk figures, however, do not take into account hearing losses above the 2000 Hz frequency. As mentioned earlier, human response to the high frequencies is more vulnerable to the adverse effects of noise, and is important to the understanding of speech in lifelike conditions. In order to compare the risk values for the mid-frequencies with those for a higher frequency, risk figures for 4000 Hz are shown. These figures were taken from Baughn's data,[8] whose risk figures for the averaged mid-frequencies were used in the calculations of EPA's and ISO's risk values. The same 25-dB hearing loss criterion is used. It can be seen that the risk is considerably greater when 4000 Hz is examined, and the differences between exposure levels are even more noticeable. While only 6 percent of the exposed population will exceed the 25 dB loss criterion at 80 dBA, 52 percent of the population will exceed it from exposure to 90 dBA. This is clearly an unacceptable risk.

Although the concept of risk appears to be a fairly straightforward way of examining the effects of noise on hearing, there are a number of reasons why EPA is reluctant to use it as the only measure. First, risk figures say nothing about the shape of the distribution. Individuals could cluster around the area of 26 dB loss or they could be scattered widely up to 50 or 60 dB. Also risk figures say nothing about hearing losses that approach, but do not exceed the criterion in question (in this case 25 dB). In other

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words, risk figures may provide information on people whose hearing goes from fair to bad, but not on those whose hearing goes from excellent to fair as a result of noise exposure. In addition, the percentage of risk will vary according to certain parameters such as the age and years of exposure of the exposed population and the presence and degree of otologic screening.[7] For these reasons, EPA believes that NIPTS, the actual amount of threshold shift due to noise exposure after correction for presbycusis, is a more appropriate descriptor of the effects of noise on hearing. While these values may appear to be less dramatic, they are less susceptible to bias and in the long run, more meaningful.

3. *Other health factors not considered.* There are certain adverse effects of noise that apparently have not even been discussed in the formulation of the standard. These are the non-auditory physiological effects of noise, and the effects on communication and job performance. While some of these effects are difficult to quantify, they should be taken into consideration as a noise exposure standard is developed, and where appropriate, they should encourage a more conservative approach to the setting of exposure limits. This is especially important in view of the fact that the proposed standard does not afford full protection against hearing loss. The Preamble states that "OSHA recognizes that comparatively more workers will be at lower risk at 85 dBA than at 90 dBA," but there is no consideration of long-range goals.

There is ample evidence that cardiovascular, endocrine and neurological changes do occur as a result of noise exposure.[2 8-26] Whether or not these changes are harmful when experienced over a lifetime is still a subject of question for American researchers. Various European and Soviet studies, as well as some American studies, have indicated that high noise levels can produce significant non-auditory physiological effects in humans.[21-26] With specific reference to industrial noise, NIOSH [7] states that:

> The fact that those who work in high noise levels show greater medical difficulties than those who work under quieter conditions is not conclusive evidence that noise is the crucial causal factor. In each case, it is possible that the differences in the specified health parameters may be explained by other factors such as age, other environmental contaminants, workload and job habits.

However, the fact that such evidence does occur, even though it is not as conclusive as the auditory evidence, is reason to approach the standard-setting process with extra caution.

NIOSH concludes the discussion by saying that the "* * * noise limits designed to provide hearing protection should also reduce the possibility of any extra-auditory health disturbance."[7] Here it should be remembered that NIOSH referred to the 85 rather than the 90 dBA level. Such a statement can be still more safely made with reference to EPA's identified levels of 70–75 dBA.

See footnotes at end of document.

While the possibility of protection against extra-auditory effects may be true for moderate levels of noise, this protection is less likely to occur with long-term exposures to 90 dBA for 8 hours, 95 dBA for 4 hours, or 100 dBA for 2 hours.

Speech and signal interference creates a similar situation. Varying amounts of communication can occur at levels above 85 dBA if talker and listener move close together and very loud voice or shouting is used. However, speech communication is almost impossible above 100 dBA[2] and the audibility of warning shouts and signals becomes increasingly problematical at such high background levels. These hazards should be acknowledged and kept in mind when setting 8-hour exposure limits, and especially when making decisions about a time-intensity tradeoff. Even with an 8-hour exposure limit of 90 dBA, adoption of a more stringent time-intensity tradeoff than the present 5 dB rule would eliminate exposure to continuous noise at levels above 105 dBA. The chances of masking warning shouts or signals, as well as the probability of auditory damage would be reduced accordingly.

The effects of noise on job performance are more difficult to quantify than the effects on speech and signal interference. Continuous noise levels above 90 dBA appear to have potentially detrimental effects on performance, depending on the type of task and the individual's physiological and motivational state.[2] Intermittent levels of less than 90 dBA can be detrimental depending upon the abovementioned variables, especially if the noise is unexpected, uncontrollable and has predominantly high frequency components.[2] Although these effects have not been studied extensively in the industrial situation, they should provide added incentive for adopting a conservative approach to the setting of standards designed to protect against other adverse effects.

B. TIME-INTENSITY TRADEOFF

OSHA's Proposal: 5-dB Rule
EPA's Recommendation: 3-dB or "Equal Energy" Rule

The question of the allowable increase in exposure levels with decrease of exposure time (time intensity tradeoff) is an issue that is as important as the 8-hour exposure level for the conservation of hearing. EPA believes that OSHA's allowable increase of 5 dB for every halving of exposure duration does not adequately protect public health and welfare. It is based on an over-simplification of the beneficial effects of intermittency. First, the criteria upon which it is based allow excessive amounts of threshold shift in the exposed population. In addition, the criteria require evenly spaced quiet intervals of specific duration in which to recover from temporary threshold shift (TTS). Such precise temporal distributions are not characteristic of the industrial environment. The typical sound levels during intermittencies in most industrial conditions are not sufficiently low to permit adequate recovery from TTS. It is generally agreed that persistent TTSs will eventually result in comparable permanent threshold shifts.[40, 41]

It is true that interrupted noise in some instances causes less damage to the hearing mechanism than an equivalent amount of continuous noise.[42, 43] For this reason, EPA increased by 5 dB the level of environmental noise identified as required to protect against hearing loss.[5] (This correction is distinct from a time-intensity tradeoff.) During the periods of interruption, the ear is able to achieve some amount of recovery from TTS. However, the amount of recovery achieved is highly dependent upon the duration and level of the noise, the amount of time between exposures and the sound level during the quiet period. While long periods of relative quiet are characteristic of most environmental noise, they are not common to industrial noise.

The 5 dB rule is theoretically based on damage-risk criteria developed by Working Group #46 of the Committee on Hearing, Bioacoustics and Biomechanics of the National Academy of Science—National Research Council (CHABA).[44] These criteria, derived from data on TTS, specify tolerable levels and durations of noise for 1-octave and 1/3-octave bands for a range of approximately 85 dB to 135 dB. They allow higher levels of noise as the durations become shorter and recovery periods become longer. Adherence to the CHABA criteria should produce TTS after 2 minutes or NIPTS after 40 years of exposure no greater than the losses displayed in Table VI. EPA believes that these are excessive amounts of allowable threshold shift from noise exposure. Moreover, research has indicated that observed amounts of TTS can be considerably higher than those predicted by the CHABA criteria.[45]

TABLE VI.—*Estimated NIPTS according to damage-risk criteria proposed by CHABA working group No. 46*

Test frequency (hertz)	Median (decibel)	90th percentile (decibel)
1000	10	30
2000	15	45
3000	20	60

The CHABA criteria were later simplified to apply to the industrial situation by consolidating the ½- and 1-octave band long- and shortburst intermittent contours into one scheme combining dBA level, total on-time and number of exposure cycles.[46] A time-intensity tradeoff was selected that seemed to characterize a situation with 5 to 7 interruptions per day, namely, a 5 dB tradeoff. The validity of even the simplified method rests on the requirements that the exposure cycles are evenly distributed and the 5 to 7 interruptions are long enough to permit the necessary amount of recovery from TTS. However, as adopted by OSHA, these requirements have disappeared. Thus, an individual can be subjected to a 95 dBA exposure level distributed in any

temporal pattern throughout the day, or even continuously, so long as a four-hour dose is not exceeded. The CHABA criteria, even in the simplified form, would permit only 80 minutes of uninterrupted exposure to 95 dBA. A yet more serious misinterpretation occurs by allowing a solid 15 minutes of exposure to 115 dBA. At this level, the CHABA criteria permit only about 3½ minutes of uninterrupted exposure.

In addition to the regularity and duration of the interruptions, the noise level of the quiet period contributes to the amount of recovery that can take place. Significantly greater amounts of TTS were found for equivalent exposures to 103 dBA when the sound level during the quiet intervals was 77 dBA than when it was 40 dBA.[46] Significant differences also appeared between quiet intervals of 67 dBA and 57 dBA.[47] This kind of evidence has prompted EPA to identify a level of 60 dBA as a quiet requirement in order to permit complete recovery from 8-hour work-day exposures no higher than 75 dBA.[4] NIOSH has identified a level of 65 dBA as meeting the requirements of a true "off-level."[7] Both figures are considerably more conservative than the 84 dBA level implicit in the proposed standard since levels below 85 dBA are not included in the calculation of the daily dose. It has been suggested that sufficiently low sound levels can heighten the effectiveness of interruptions and facilitate recovery that otherwise would not occur.[48] This hypothesis could very well explain the advantages attributed to intermittency in the laboratory and in occupations such as forestry and some kinds of mining where the background noise level is fairly low. Obviously, there is quite a differences between a remote mountain top and a typical production factory.

It is generally agreed that the noise in production industries is fairly continuous or steady-state in nature and that it is not intermittent, i.e., interrupted by periods of subjective silence[8] or by noise levels below 55 dBA[8] to 65 dBA[7] depending on the definition of intermittency. OSHA's draft Environmental Impact Statement[49] maintains that "most industrial operations emit steady-state sounds." For this type of noise there is widespread agreement that the "equal energy" rule holds true, that is that equal amounts of sound energy will cause equal amounts of hearing loss regardless of how the energy is distributed in time. This rule allows a 3 dB increase in exposure level with each halving of exposure duration, rather than the 5 dB increase permitted by OSHA. The concept of equal energy is incorporated into the ISO Recommendation R1999 "Assessment of Occupational Noise Exposure for Hearing Conservation Purposes,"[50] it is written into most European standards for occupational noise,[51-53] and it is used in modified form in the U.S. Army[54] and U.S. Air Force[57] standards. Actually, the Army has adopted a standard that identifies any level above 85 dBA as potentially hazardous, regardless of duration (i.e., a more conservative approach than the 3 dB tradeoff). The Air Force, although it previously used the equal energy rule,[56] has adopted a 4 dB tradeoff.[57] presumably as a compromise between the equal energy rule and the present OSHA method. The equal energy rule is incorporated into the methodology by which EPA has identified safe levels of environmental noise.[4] According to the EPA/AMRL criteria[3] the equal energy rule "is probably the best available method of predicting the effect of noise on hearing in the case of continuous noise of which the level fluctuates slowly (seconds to hours) during the workday," and its application to these noise conditions is advocated by most contemporary researchers.[37 59-61] Experimental support has been given to its application to intermittent noise[37 46 48] and there is a growing tendency to apply the rule to impulsive noise as well[4 64-68] (see Appendices C and G of EPA's "Noise Levels Document"). The English Code of Practice[51] extends the equal energy rule from completely steady-state noise to short-duration impulses as high as 150 dB. There is no doubt that the equal energy rule is simpler, and it is more practical to use since OSHA's 5 dB time-intensity tradeoff imposes limits of 115 dBA on continuous noise and 140 dB on impulsive noise.

An additional point that may have very serious implications for noise control is the fact that noise exposure can produce structural damage to the ear that is not demonstrated by behavioral audiometry.[37] A scheme such as the CHABA method, which is based on the growth and recovery of TTS, neglects the possibility that anatomical damage may occur even though it is not detected by ordinary methods. Thus, damage risk criteria that appear to be safe as measured by TTS and subsequent recovery may fail to protect individuals from physiological damage that might become apparent after years of exposure.

For the above reasons, a 5-dB time-intensity tradeoff is not appropriate to the industrial environment. Employing it would not protect public health and welfare to the extent required. It would allow excessive amounts of NIPTS, particularly in the more susceptible members of the exposed population (see Table VI), even if the CHABA-recommended intermittency patterns were adhered to. As the rule is currently interpreted, 4 hours of continuous noise at 95 dBA, and likewise 2 hours of continuous noise at 100 dBA and 15 minutes at 115 dBA are allowable, with the resulting amounts of hearing loss potentially much greater than those predicted by the CHABA criteria. These points are among the many reasons to severely restrict exposure to noise levels as high as 110 dBA and 115 dBA, and to apply the more conservative equal energy rule to industrial noise exposures.

III. Feasibility, Technology and Cost

To fill the gap in data, which was pointed to in the NIOSH criteria document, the Department of Labor commissioned Bolt, Beranek, and Newman to study the cost and technology of quieting industry to levels of 90 dBA and 85 dBA. As that study showed, the same technology that is available today to achieve a level of exposure to 90 dBA for 92 percent of the workforce can also be applied to achieve a level of 85 dBA for the same number of workers, and that technology can be adequately supplied by the noise control industry. The cost of achieving the 85 dBA level is, of course, greater. However, EPA believes that many of BBN's estimates ($13.5 billion for 90 dBA, $18.1 billion more for 85 dBA) are too high. BBN's report (because of the short time given for it) includes cost data based wholly or in part on extrapolations from individual plants to whole industries, and from smaller industries to very large industries, which could also produce questionable figures. An example is the use of relative gross annual value of production to compare lumber finishing operations with saw mills, where the control requirements are not directly similar. In addition, it appears that estimates were not based on least cost methodology.[58] The final cost estimates do not take into account the combined use of administrative and engineering controls as allowed by the proposed standard, nor do they include the possibility of using in-house labor to achieve noise reduction.

Also, the estimates of economic impact do not consider as an offsetting savings the beneficial effect of new, quieter machinery on capital and labor productivity. Furthermore, alternatives such as those indicated in Part IV of this document can also favorably alter the cost impact. For these kinds of reasons, EPA suggested that a more thorough study of costs and benefits should be performed.

Even assuming, however, that these figures are correct, EPA believes that, in view of the need to reduce the standard ultimately to 75 dBA in order to protect the population adequately, requiring compliance with an 85 dBA standard within three years is a reasonable first step. The added protection is commensurate with even the BBN calculations of added cost. As shown in Tables III and IV, 8,120,000 more workers are protected at 85 dBA than at 90 dBA.

IV. Suggested Alternatives

EPA recognizes that, in the final analysis, it is OSHA that must perform the balancing of the cost, technology and health and welfare considerations. We believe, however, that for the reasons discussed above, the standards proposed and the justification given by OSHA fall short of protecting the health and welfare of workers to the extent required or to the extent that these values could feasibly be protected. Accordingly, EPA is asking that OSHA address in detail the specific points discussed above. If after doing so, the Secretary determines that an 85-dBA standard (and 3 dB time-intensity tradeoff) applicable to all industries after three years is not justified, the following regulatory alternatives should be considered. Because each of

See footnotes at end of document.

these approaches has been previously suggested to OSHA, and all have been rejected without explanation, the Administrator requests that the detailed response to this notice include a detailed discussion of the Secretary's findings as to whether any one or a combination of these approaches could feasibly be employed to more adequately protect the public health and welfare.

In considering alternatives, EPA would urge OSHA not to abandon its position that the use of hearing protectors and audiometric monitoring are merely supplementary measures. EPA approves of OSHA's inclusion of hearing conservation measures as an integral part of an occupational noise control program. EPA concurs with the approach traditionally held by OSHA that ear protective devices should be used as interim measures until such time as engineering or administrative controls can reduce noise exposure to safe levels. However, since ear protective devices are often improperly used or not used, EPA does not view such devices as a viable alternative to noise reduction at the source or the use of administrative controls. Moreover, there exist with the use of such devices, as with many other personal protective items, possible risks of increased safety hazards.

EPA believes that audiometric monitoring can be a valuable diagnostic tool, but it will not detect "any changes in hearing," and consequently prevent significant threshold shift as OSHA has stated in its preamble. Normal variability among subjects, audiometers and technicians will reduce the probability of detecting hearing losses before they become significant. Moreover, OSHA's definition of significant threshold shift would conceivably allow threshold shifts of up to 35 dB at a single frequency before the worker is appraised of his hearing loss. Even at that point, there are no remedial steps specified except for retraining in the use of ear protection. For these reasons, EPA concurs with OSHA that hearing protection devices and audiometric testing alone cannot be considered as an alternative method of achieving noise reduction.

1. *Industry-by-industry standards.* Bolt, Beranek and Newman pointed out in its feasibility study that a small portion of the American production industries is presently unable to comply with a 90-dBA 8-hour exposure standard with existing noise control technology.[8] In addition, some industries will experience the economic impact of compliance much more severely than others. Presumably for these reasons OSHA has chosen to issue extended compliance intervals for certain industries. Such an agreement is currently in effect with the American Can Company and EPA understands that agreements with other large companies are being negotiated. In addition, a multitude of abatement extensions are currently being granted on the local level. By granting different extensions to different industries OSHA has shown that industry-by-industry standards are administratively feasible, and in a sense, are being practiced. Setting a more stringent goal for all industries and then allowing different compliance schedules for different industries would be one method of approaching the problem. This method could have the advantage of immediate reductions to noise levels well below 90 dBA wherever such reductions are feasible. Reductions in some cases to levels as low as 75 dBA, would preclude even small amounts of threshold shift in most of the exposed population, and would greatly reduce the potential hazard of non-auditory effects.

2. *Incremental reductions.* This alternative is a variation of the plan mentioned above, where all industries would be required to comply with a certain exposure level within, for example, 5 years, and another level in another 5 years and so on until a truly safe level is achieved. It would be less complicated to administer than the industry-by-industry plan, but would not provide such immediate protection for workers employed in industries where abatement to low noise levels is readily achievable. In earlier drafts of OSHA's noise standard (Working Drafts I and II), reduction to 85 dBA in 5 years was specified. That provision has since been deleted. EPA strongly recommends that either the 5-year, or better, the 3-year provision be reinserted with serious consideration given to reducing to 80 dBA after another subsequent period.

3. *Stringent standard with variance provisions.* This alternative involves setting more stringent industry-wide standards, and allowing temporary variances for individual companies that are economically or technologically unable to comply. The agreement with the American Can Company has set clear precedent for the use of variances, even though the word "variance" has not been attributed to the agreement. The concept should be considered not only in terms of the present 90-dBA standard, but with respect to levels of 85 dBA and eventually to 80 dBA. It should, naturally, be viewed in terms of longer compliance periods for the lower levels, and for the companies that would experience the greatest economic and technical difficulties.

4. *Lower levels for new plants.* NIOSH has recommended that new plants be designed to meet an 85-dBA standard. This should be technologically feasible for nearly all industries, and the economic burden would be smaller than it would be for reducing exposures in existing plants. Requiring more stringent standards for new plants would stimulate the development of cost effective noise abatement technology and it would ease the burden of noise abatement requirements in the future.

Dated: December 6, 1974.

RUSSELL TRAIN,
Administrator,
Environmental Protection Agency.

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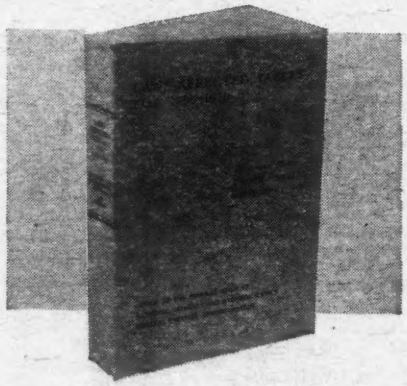
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